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# IMPACT OF DESIGN THINKING-BASED CHEMISTRY INSTRUCTION ON CONCEPT APPLICATION SKILLS AMONG SECONDARY SCHOOL STUDENTS

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**Abstract**

***This study investigates the impact of design thinking-based chemistry instruction on the concept application skills of secondary school students. Traditional chemistry teaching often focuses on memorization rather than the practical application of concepts. Design thinking, a problem-solving approach that encourages creativity, empathy, and experimentation, was integrated into chemistry instruction to enhance students' understanding and application of scientific concepts. A quasi-experimental research design was adopted with control and experimental groups consisting of secondary school students. The experimental group was taught using design thinking-based instructional strategies, while the control group followed traditional teaching methods. Data were collected using concept application tests and analyzed using statistical methods. The findings revealed that students exposed to design thinking-based instruction demonstrated significantly higher concept application skills compared to those taught through conventional methods. The study highlights the potential of design thinking as an effective pedagogical approach in chemistry education.***

**Keywords:** *Design Thinking, Chemistry Education, Concept Application Skills, Secondary School Students, Innovative Teaching*

## Introduction

Chemistry is one of the fundamental branches of science that helps students understand the composition, structure, properties, and changes of matter. It plays a significant role in explaining many natural phenomena and contributes to various fields such as medicine, agriculture, environmental science, and industrial development. Learning chemistry not only enhances scientific knowledge but also develops analytical thinking and problem-solving abilities among students. In secondary school education, chemistry forms a crucial part of the science curriculum and provides the foundation for higher studies in science and technology.

Despite its importance, many students face difficulties in understanding and applying chemistry concepts. Traditional teaching methods in chemistry classrooms often rely heavily on lecture- based instruction, memorization of formulas, and textbookoriented learning. Such approaches may help students acquire theoretical knowledge but often fail to promote deeper conceptual understanding and practical application of scientific ideas. As a result, students may struggle to relate chemistry concepts to real-life situations or to solve practical problems using their knowledge.

In recent years, educators have emphasized the need for innovative teaching strategies that promote active learning and student engagement. One such approach is design thinking, which is widely recognized as an effective method for enhancing creativity, collaboration, and problem- solving skills. Design thinking is a human-centered approach to problem-solving that encourages learners to identify problems, explore possible solutions, and develop innovative ideas through experimentation and reflection. The process typically involves five stages: empathy, defining the problem, ideation, prototyping, and testing.

When applied in educational settings, design thinking encourages students to actively participate in the learning process rather than passively receiving information. In the context of chemistry education, design thinking can enable students to investigate scientific problems, design experiments, and develop practical solutions using chemical concepts. This approach not only improves conceptual understanding but also strengthens students' ability to apply scientific knowledge in real-world contexts.

Therefore, integrating design thinking into chemistry instruction may significantly enhance students' concept application skills and promote meaningful learning. In this regard, the present study aims to examine the impact of design thinking-based chemistry instruction on the concept application skills among secondary school students. The study seeks to determine whether this innovative teaching approach can improve students' ability to apply chemistry concepts effectively compared to traditional teaching methods.

**Statement of the Problem**

Chemistry plays an important role in helping secondary school students understand scientific concepts and apply them to real-life situations. However, many students find it difficult to apply the theoretical knowledge they learn in the classroom to practical problems. In many schools, chemistry teaching is still focused mainly on memorization of formulas, reactions, and definitions rather than encouraging students to think critically and apply concepts in different contexts.

Traditional lecture-based teaching methods often provide limited opportunities for students to actively participate in learning. As a result, students may not fully develop their concept application skills or problem-solving abilities. This can reduce their interest and understanding of chemistry as a practical subject.

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Design thinking is a learner-centered approach that encourages creativity, collaboration, and problem-solving. By involving students in identifying problems and exploring possible solutions, this method may help improve their ability to apply chemistry concepts effectively.

Therefore, this study aims to examine the impact of design thinking-based chemistry instruction on the concept application skills of secondary school students.

**Need for the Study**

Chemistry education at the secondary school level often focuses more on memorizing concepts than on applying them in practical situations. As a result, many students face difficulties when they are required to use their knowledge to solve real-life problems. This shows the need for teaching methods that promote deeper understanding and practical application of chemistry concepts.

Design thinking is an approach that encourages students to think creatively, analyze problems, and develop possible solutions. Introducing design thinking into chemistry instruction may help students improve their concept application skills and engage more actively in the learning process. Therefore, this study is needed to examine whether design thinking-based chemistry instruction can enhance the ability of secondary school students to apply chemistry concepts effectively. The findings of this study may help teachers adopt more effective and student-centered teaching strategies in chemistry classrooms.

**Scope of the Study**

- The study focuses on the use of **design thinking-based instruction in teaching chemistry**.
- It is limited to **secondary school students studying chemistry**.
- The research examines the **concept application skills of students** in chemistry.
- The study considers **selected chemistry topics** included in the secondary school syllabus.
- It evaluates how **design thinking activities influence students' understanding and** application of concepts.
- The findings are intended to help improve **teaching methods used in chemistry classrooms**.

**Hypotheses**

- $H_{01}$: There is no significant difference between the pre-test and post-test scores of the control group in terms of concept application skills in chemistry.

- $H_{02}$: There is no significant difference between the pre-test and post-test scores of the experimental group in terms of concept application skills in chemistry.
- $H_{03}$: There is no significant difference between the post-test scores of the control group and the experimental group in concept application skills in chemistry.
- $H_{04}$: There is no significant difference between boys and girls in the post-test scores of the experimental group in concept application skills in chemistry.

**Limitations of the Study**

- ➢ The study was limited to a selected group of secondary school students, which may restrict the generalization of the results to a larger population.
- ➢ The research focused only on selected topics in the chemistry syllabus rather than the entire curriculum.
- ➢ The duration of the instructional intervention was limited to a short period of time.
- ➢ The effectiveness of the design thinking approach may vary depending on the teacher's method of implementation.
- ➢ Individual differences among students such as learning ability, prior knowledge, and interest in chemistry were not fully controlled during the study.

**Research Methodology**

The present study adopted a quantitative research approach to examine the impact of design thinking-based chemistry instruction on the concept application skills of secondary school students. A quasi-experimental method was used to compare the effectiveness of design thinking- based instruction with the conventional teaching method. The study involved two groups of students: an experimental group and a control group.

The experimental group was taught chemistry using design thinking-based instructional strategies, while the control group received instruction through the traditional lecture method. A pre-test was conducted before the instructional intervention to assess the students' initial level of concept application skills. After the completion of the instructional period, a post-test was administered to evaluate the improvement in students' concept application skills.

The collected data were analyzed using appropriate statistical techniques to determine the effectiveness of the instructional approach. The methodology helped in identifying whether design thinking-based instruction had a significant influence on improving students' ability to apply chemistry concepts.

**Design of the Study**

**The study adopted a** quasi-experimental pre-test and post-test control group design**.**

Two groups of secondary school students were selected for the study: **experimental group and control group**. The **experimental group** was taught chemistry using **design thinking-based instructional strategies**. The **control group** received chemistry instruction through **traditional teaching methods**. A **pre-test** was conducted for both groups to determine the students' initial level of concept application skills in chemistry. After the instructional intervention, a **post-test** was administered to measure the improvement in students' concept application skills. The design helped in comparing the **effectiveness of design thinking-based instruction with conventional teaching methods**.

**Sample of the Study**

- The sample of the present study consisted of 60 secondary school students studying in Standard XI.
- The students were selected from a recognized higher secondary school in Chennai, Tamil Nadu.
- The participants were divided into two groups, namely the experimental group and the control group, with 30 students in each group.
- The experimental group received chemistry instruction through design thinking-based teaching strategies, while the control group was taught using traditional teaching methods.
- The sample was selected using an appropriate sampling technique suitable for the research design.
- The selected sample size was considered adequate for conducting the study and analyzing the effectiveness of the instructional approach.

**Ethical Clearance Statement**

The study was conducted following standard ethical guidelines in educational research. Permission to carry out the research was obtained from the school administration before the beginning of the study. The participants were informed about the purpose of the research, and their participation was voluntary.

Confidentiality of the information collected from the students was maintained throughout the study. The data gathered were used only for academic research purposes, and the identity of the participants was kept anonymous.

**Variables of the Study**

- **Independent Variable:** Design thinking-based chemistry instruction.
- **Dependent Variable:** Concept application skills in chemistry among secondary school students.
- **Control Variables:** Grade level (Standard XI), school environment, selected chemistry topics, and duration of instruction.
- Permission was obtained from the school authorities to conduct the study.

- The sample of students was selected and divided into experimental and control groups.
- Lesson plans and instructional materials were prepared for both groups.

**Phase II – Pre-Test**

- A pre-test was administered to both groups to assess their initial level of concept application skills in chemistry.

**Phase III – Instructional Intervention**

- The experimental group received chemistry instruction through design thinking-based teaching strategies.
- The control group was taught the same topics using traditional teaching methods.

**Phase IV – Post-Test**

- After the completion of the instructional period, a post-test was conducted for both groups.
- The collected data were recorded and prepared for statistical analysis to determine the effectiveness of the instructional approach.

**Statistical Techniques Used**

Descriptive statistics such as mean and standard deviation were used to analyse the overall performance of the students. Inferential statistics, particularly the t-test, were applied to determine the significance of the difference between the pre-test and post-test scores of the students. The statistical analysis helped in examining the effectiveness of design thinking-based chemistry instruction on students' concept application skills.

**Data Analysis and Interpretation**

The data collected from the **pre-test and post-test** were analyzed using appropriate statistical methods to determine the effectiveness of design thinking-based chemistry instruction on students' concept application skills. The scores obtained by the students in both the experimental and control groups were carefully examined.

Descriptive statistics such as **mean and standard deviation** were calculated to understand the overall performance of the students. In addition, **inferential statistics**, particularly the **t-test**, were used to test the stated hypotheses and identify whether there was a significant difference between the groups.

The analysis and interpretation of the data helped in understanding the impact of the instructional approach on improving students' ability to apply chemistry concepts effectively.

**$H_{01}$:** There is no significant difference between the **pre-test and post-test scores of the control group** in terms of concept application skills in chemistry.

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**Table-1**

**Table-1 presents the Level of Statistically Significant between Control Group and Experimental Group Boys in Post Test in Achievement in Chemistry**

| Sl. No | Description | C.G.Boys | E.G.Boys |
|---|---|---|---|
| 1 | N | 15 | 15 |
| 2 | Mean | 28.124333 | 33.4444333 |
| 3 | Median | 26 | 33 |
| 4 | Mode | 26 | 34 |
| 5 | SD | 2.83305515 | 3.163925134 |
| 6 | HighestScore | 34 | 43 |
| 7 | LowestScore | 25 | 31 |
| 8 | Range | 10 | 13 |
| 9 | tvalue | 4.86 | |
| 10 | Levelof Statistically Significant | StatisticallySignificant | |

- The mean post-test score of the **Experimental Group Boys (34.44)** is **higher** than that of the Control Group Boys (28.12).
- The **standard deviation** is relatively similar, suggesting comparable variance in both groups.
- The **t-value = 4.86** is statistically significant at $p < 0.01$ level, indicating a **very strong difference** between groups.

**Conclusion**: The calculated t-value **($t = 4.86$, $p < 0.001$)** indicates a statistically significant difference between the control and experimental groups. Therefore, **the null hypothesis is rejected**. The experimental group boys performed significantly better than the control group boys in the post-test.

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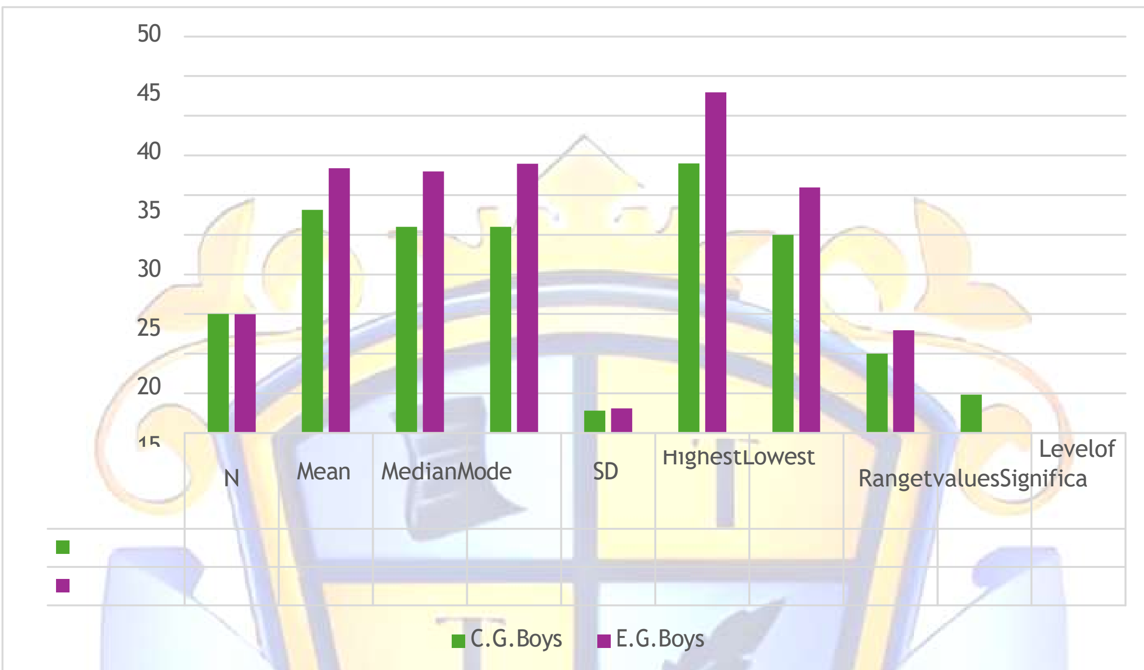
## Graph-1

**Graph-1 present the Level of Statistically Significant between Experiment Group and Control Group Boys in Post Test in the Achievement in Chemistry**



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**Hypothesis-II**

- There is no significant difference between control group and experimental group girls in Post Test

**Table-2**

**Table-2 presents the Level of Statistical Significance between Control Group and Experimental Group Girls in the Post-Test of Concept Application Skills in Chemistry.**

| Sl. No | Description | C.G. Girls | E.G. Girls |
|---|---|---|---|
| 1 | N | 15 | 15 |
| 2 | Mean | 28.3333 | 33.5666 |
| 3 | Median | 28 | 31 |
| 4 | Mode | 27 | 33 |
| 5 | SD | 3.309416 | 2.820321 |
| 6 | Highest Score | 33 | 42 |
| 7 | Lowest Score | 23 | 29 |
| 8 | Range | 10 | 13 |
| 9 | t value | 4.66 | |
| 10 | Level of Significance | Statistically Significant | |

➤ The **Experimental Group Girls obtained a higher mean score (33.56)** than the **Control Group Girls (28.33)**.

➤ The **lower SD value in the experimental group indicates more consistency** in performance.

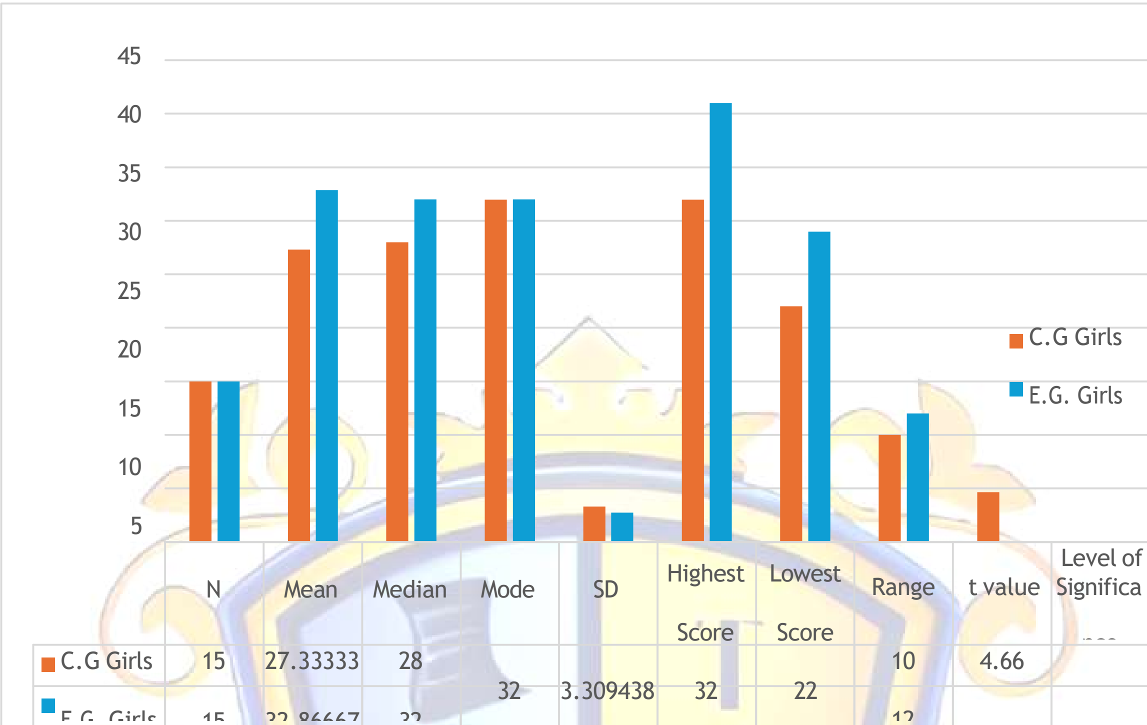
➤ The **t-value = 4.66**, which is statistically significant at **$p < 0.01$ level**.

**Conclusion**

The calculated **t-value ($t = 4.66$, $p < 0.01$)** indicates a **significant difference between the control group and experimental group girls** in the post-test scores of concept application skills in chemistry. Therefore, the **null hypothesis is rejected**. The **experimental group girls performed better than the control group girls**.

**Graph 2**

**Graph-2 presents the Level of Statistically Significant between Control Group and Experiment Group Girls in Post Test in Achievement in**




**Chemistry**

- **Hypothesis-III**

  There is no significant difference between Control group and Experiment group Rural students and their Post Test Scores

**Table – 3**

**Table-3 presents the Level of Statistical Significance between Control Group and Experimental Group Rural Students in the Post-Test of Concept Application Skills in Chemistry**

| SL.No | Description | C.G RURAL | E.G. RURAL |
|---|---|---|---|
| 1 | N | 21 | 19 |
| 2 | Mean | 26.82 | 32.40 |
| 3 | Median | 30 | 34 |
| 4 | Mode | 29 | 34 |
| 5 | Sd | 2.88 | 3.34 |
| 6 | Highest score | 32 | 43 |

| | | | |
|---|---|---|---|
| 7 | Lowest score | 23 | 29 |
| 8 | Range | 10 | 12 |
| 9 | T value | 5.62 | |
| 10 | Level of significance | Statistically Significant | |

- Rural students in the **Experimental Group** scored significantly higher (Mean = 32.40) than those in the Control Group (Mean = 26.82).
- The **t-value = 5.62** is **extremely significant** ($p < 0.01$), indicating a highly reliable difference.

**Conclusion**: The calculated t-value **($t = 5.62, p < 0.001$)** indicates a statistically significant difference between rural students in the control and experimental groups. Therefore, **the null hypothesis is rejected.** The experimental group rural students performed significantly better than the control group rural students in the post-test.

**Interpretation**

➢ The Experimental Group Rural students obtained a higher mean score (32.40) compared to the Control Group Rural students (26.82).

➢ The standard deviation values are close, showing similar variation in student performance.

➢ The calculated t-value = 5.62, which is statistically significant at $p < 0.01$ level.

**Conclusion**

The calculated t-value ($t = 5.62, p < 0.01$) indicates that there is a significant difference between control group rural students and experimental group rural students in the post-test scores of concept application skills in chemistry. Therefore, the null hypothesis is rejected. The experimental group rural students performed better than the control group rural students.

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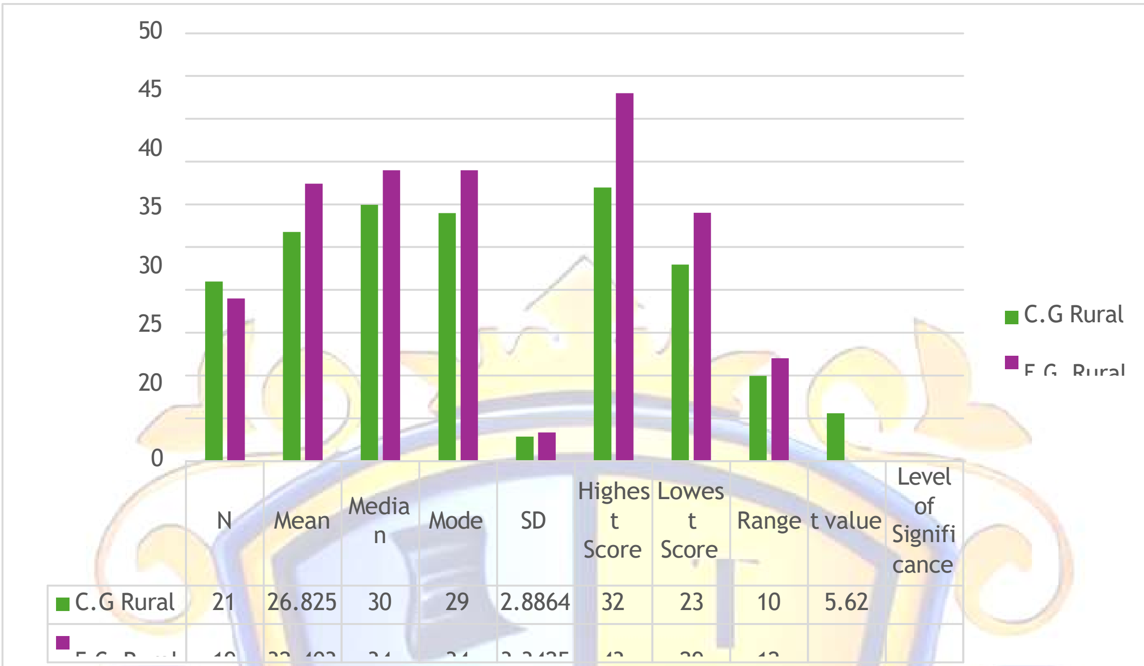
**Graph – 3**

**Graph-3 shows the comparison between Control Group Rural students and Experimental Group Rural students in the post-test of Concept Application Skills in Chemistry.**




**Hypothesis - IV**

- There is no significant difference between Control group and Experiment group Urban students and their Post Test Scores

**Table 4**

**Table-4 presents the level of Statistically Significant between the Experiment Group and Control Group Urban Students and their Post Test in the Achievement of Chemistry**

| Sl. No | Description | C.G. Urban | E.G. Urban |
|---|---|---|---|
| 1 | N | 10 | 11 |
| 2 | Mean | 27.5551 | 32.545361 |
| 3 | Median | 27 | 32 |
| 4 | Mode | 26 | 32 |
| 5 | SD | 1.739267 | 3.479271 |
| 6 | Highest Score | 32 | 36 |

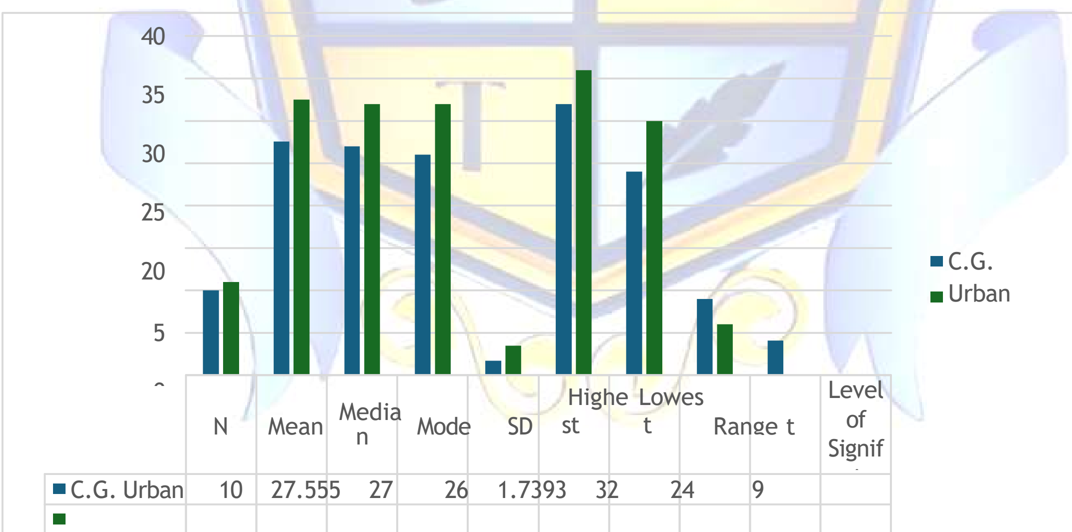
| | | | |
|---|---|---|---|
| 7 | Lowest Score | 24 | 30 |
| 8 | Range | 9 | 6 |
| 9 | t value | 4.08 | |
| 10 | Level of Statistically Significant | Statistically Significant | |

- Urban students in the **Experimental Group** scored higher (Mean = 32.54) than the Control Group (Mean = 27.55).
- The **SD is lower** in the experimental group, indicating greater consistency in scores.
- The **t-value = 4.08** is statistically significant ($p < 0.01$).

**Conclusion**: The calculated t-value **(t = 4.08, p < 0.001**) indicates a statistically significant difference between urban students in the control and experimental groups. Therefore, the null hypothesis is rejected. The experimental group urban students performed significantly better than the control group urban students in the post-test.

**Graph-4**

**Graph-4 shows the comparison between Control Group Urban students and Experimental Group Urban students in the post-test of Concept Application Skills in Chemistry.**




The calculated t-value **(t = 4.08, p < 0.001**) indicates a statistically significant difference between urban students in the control and experimental groups. Therefore, **the null hypothesis is rejected**. The experimental group urban students performed significantly better than the control group urban students in the post-test.

**Findings**

1. The results revealed that boys in the experimental group performed better than boys in the control group in the post-test of concept application skills in chemistry. The higher mean score indicates that design thinking-based instruction had a positive effect on their learning.
2. The findings showed that girls in the experimental group achieved higher scores than girls in the control group in the post-test. This suggests that the design thinking approach helped improve their understanding and application of chemistry concepts.
3. The analysis indicated that rural students in the experimental group performed significantly better than rural students in the control group. This shows that the instructional strategy was effective for students from rural backgrounds.
4. The results also showed that urban students in the experimental group obtained higher mean scores than urban students in the control group in the post-test.
5. Overall, the findings of the study indicate that design thinking-based chemistry instruction improved the concept application skills of secondary school students compared to conventional teaching methods.

**Discussion**

The results of the present study indicate that design thinking-based chemistry instruction had a positive impact on the concept application skills of secondary school students. The experimental group consistently performed better than the control group in the post-test results. This suggests that the instructional strategy helped students understand and apply chemistry concepts more effectively.

One possible reason for this improvement is that the design thinking approach encourages active participation and problem-solving during the learning process. Unlike traditional teaching methods, which mainly focus on memorization and lecture-based instruction, design thinking allows students to explore ideas, identify problems, and develop possible solutions. This process helps students connect theoretical knowledge with practical situations. The findings also show that the improvement was observed among both boys and girls, as well as among rural and urban students. This indicates that the design thinking approach can be applied effectively across different groups of learners.

Overall, the results of the study highlight the importance of using innovative and student-centered teaching strategies in chemistry classrooms. Such approaches can enhance students' understanding, promote critical thinking, and improve their ability to apply scientific concepts in meaningful ways.

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**Conclusion**

The present study examined the effectiveness of design thinking-based chemistry instruction in improving the concept application skills of secondary school students. The results of the study showed that students who were taught using the design thinking approach performed better than those who were taught using traditional teaching methods.

The experimental group demonstrated higher post-test scores compared to the control group, indicating that the instructional strategy helped students apply chemistry concepts more effectively. The improvement was observed among boys and girls as well as among rural and urban students.

The findings suggest that integrating design thinking into chemistry teaching can promote active learning, enhance conceptual understanding, and improve students' ability to apply knowledge in practical situations. Therefore, design thinking-based instruction can be considered an effective teaching approach for improving the learning outcomes of secondary school students in chemistry.

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